MULTI-PLATFORM GEOLOCATION METHOD AND SYSTEM

FIELD OF THE INVENTION

The present generally relates to the method and system for locating a source of electromagnetic radiation, and in particular, a system and method for processing angle of arrival, time difference of arrival, and/or terrain altitude measurements to determine a location of an emitter (e.g., radio or microwave).

BACKGROUND OF THE INVENTION

Various methodologies and techniques have been developed over the years for the purpose of locating or determining the geolocation of radio frequency transmitters or emitters. And, in order to meet the requirements of a recent Federal Communications Commission (FCC) Ruling and Order, whereby cellular the phone service providers in the United States must provide a capability to locate the position of a cellular phone making an emergency call within the cellular phone service provider's system to within 125 meters with about a 67% probability, new techniques and methodologies have been developed to increase location accuracy in order to meet the requirements of this FCC Ruling and Order. U.S. Pat. No. 5,987,329 entitled "System and Method for Mobile Telephone Location Measurement Using a Hybrid Technique" outlines a number of techniques that have been developed and that are currently being developed to meet the FCC's Ruling and Order, among other requirements. However, and as noted in U.S. Pat. No. 5,987,329, except for the Global Positioning System (GPS), most current location measurement techniques and approaches do not meet the FCC mandate.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to provide a system and methodology for determining the geolocation of a source of electromagnetic radiation or an emitter with increased accuracy over conventional systems and methodologies.

It is a further object of the present invention to provide a system and method for providing geolocation information of an emitter with an estimate of the accuracy of such geolocation determination.

It is still another object of the present invention to provide a geolocation system and methodology capable of estimating and removing time difference of arrival ("TDOA") biases from certain measurements.

The method and system of the present invention achieves one or more of these objectives by providing a method and system which utilizes measurements taken from several different locations simultaneously. Such measurements may include angle of arrival measurements, relative time of arrival of pulses at two or more locations, and terrain altitude estimate information for the emitter. The system and method of the present invention is also adapted to provide location uncertainty information, accounting for both random noise and bias sources. In one embodiment, the method for locating the first emitter includes the steps of receiving at first and second platforms a first signal (e.g., a pulse or a continuous wave) emitted from the first emitter, determining a first angle of arrival and/or a first time of arrival of the first signal at the first platform, determining a second angle of arrival and/or a second time of arrival of the first signal at the second platform, receiving a first altitude estimate of the first emitter, and determining a first location estimate of the first emitter using the first angle of arrival and/or the first time of arrival of the first signal at the first platform, the second angle of arrival and/or the second time of arrival of the first signal at the second platform, and the first altitude estimate of the first emitter. The first altitude estimate may be independent of the first and second angles of arrival at the first and second platforms, respectively, and may be retrieved from a database containing terrain information in the area where the first emitter is estimated to be located. In another embodiment, the step of determining the first location estimate includes performing a least squares analysis and/or a Kalman filter analysis using the first and second angles of arrival of the first signal at the first and second platforms, respectively, the first and second times of arrival of the first signal at the first and second platforms, and/or the first altitude estimate of the first emitter.

In another embodiment, the method may further include the step of receiving an initial location estimate for the first emitter. Such initial location estimate may be obtained from available information sources (e.g., a database) or may be determined in a number of ways. In this regard, the step of receiving the initial location estimate may comprise performing one of the steps of determining the initial location estimate from a first intersection of the first and second angles of arrival of the first signal at the first and second platform, respectively, the first platform being remote from the second platform, determining the initial location estimate from a second intersection of the first angle of arrival and a third angle of arrival of the first signal at the first platform and a third platform, respectively, the first platform being remote from the third platform, and determining the initial location estimate from a third intersection of the third angle of arrival and a fourth angle of arrival of the first signal at the third platform and a fourth platform, respectively, the third platform being remote from the fourth platform. Alternatively, the initial location estimate can be determined from a first intersection of the first angle of arrival of the first signal and second angle of arrival of a second signal at the first platform at another point in time if the first platform is moving. In this regard, the initial location estimate or guess may be performed by finding the intersection of angle of arrival measurements from at least two geometrically separated platforms or sensors for receiving signals from the emitter, or one platform or sensor which moves between two different times. In another embodiment, the initial location estimate may be determined by a first intersection of a first pointing direction with a ground surface, the first pointing direction corresponding to a first azimuth and first elevation of the first angle of arrival of the first signal at the first platform, or from a second intersection of a second pointing direction with the ground surface, the second pointing direction corresponding to a first azimuth and a first elevation of a third angle of arrival of the first signal at a third platform.

In another embodiment, an expected measurement set can be determined from the known positions of the platforms (e.g., first and second platforms), and the initial location estimate. In this regard, an expected TDOA measurement may be obtained. A difference or residual between each actual measurement set (e.g., angle of arrival, time difference of arrival and/or altitude estimate) and the predicted or expected measurement set will, in general, exist. This residual arises from error in the initial location estimate and measurement noise. The method of the present invention uses this residual or difference between the actual measurements and the predicted measurements to update the initial